

Realizing Practical Nitinol Locomotion

Completed Technology Project (2014 - 2016)



Project Introduction

Historically motors and solenoids use coils of conductive wire to generate electrically driven magnetic motion, and pneumatic driven solenoids have been used for producing motion from fluidic pressures. Present day Nitinol memory alloys have opened new possibilities to create locomotion via solid state actuators. This technology offers innovative approaches to address the energy conversion technological topics in the Space Technology Roadmap under the TA03.01 Energy Harvesting Technology Development Subtopic. Nitinol wires are unique nickel-titanium alloys that shorten in length when heated; they expand and contract because of the combination of nickel and titanium crystalline structures. Nitinol wire is much stronger than an average strand of wire, is capable of doing more work with less energy, is easy to use, small in size, operates silently, lightweight, and is easily activated using AC or DC power. In 1973, Nitinol was used to create the first solid state heat engine, and memory alloys currently have the potential to considerably change thermal energy conversion technology. However, contraction readily occurs when electrical excitation rapidly heats the Nitinol material, but expansion, which occurs when the material is cooled, is more difficult to rapidly achieve. Cooling is still a technological challenge that needs to be overcome in order to optimize utility of this technology. Developing and employing Electrostatic Fluid Acceleration (EFA) techniques for advancing the controllability of Nitinol materials will unlock the potential of the Nitinol material for practical deployment applications. In addition to energy conversion, this kind of device also potentially has practical applicability for accessing and transporting hardware components used throughout the ground propulsion test facilities which in turn, would reduce operational costs.

This project will demonstrate advancements in the technology's practicality by using low levels of electrical power to move significant objects in order to avoid the added complications with energy harvesting devices. A lightweight power efficient miniaturized crawler for retrieving and shelving stored items via an advanced Nitinol wire locomotion device utilizing a novel cooling mechanism will be developed and constructed. The system will be designed and built to demonstrate practical locomotion from the novel Nitinol control apparatus. Nitinol wires shorten in length when heated. The wire accomplishes 5% contraction of its full length by becoming expandable when cooled, and stiffening back into its original length when heated. Advanced cooling, for expansion, will be achieved through EFA technologies. EFA has experimentally exhibited an ability to alter the boundary layer along a fixed surface for achieving increased thermal transfer or thermal isolation. The crawler mechanism will be constructed from two Nitinol controlled latching levers with an interconnecting Nitinol controlled linear actuator to produce a caterpillar-like locomotion. The unit will traverse structures made from aluminum x-rails with a Nitinol grabber capable of maneuvering large heavy objects onto shelving. The Nitinol actuation devices will be energized with an electrostatic field for increasing air flow to enhance cooling into nearby thermal sinks for

Technology Transfer Program
Logo

Table of Contents

Project Introduction	1
Anticipated Benefits	2
Primary U.S. Work Locations and Key Partners	2
Organizational Responsibility	2
Project Management	2
Images	3
Project Website:	3
Technology Maturity (TRL)	3
Technology Areas	3

Realizing Practical Nitinol Locomotion

Completed Technology Project (2014 - 2016)



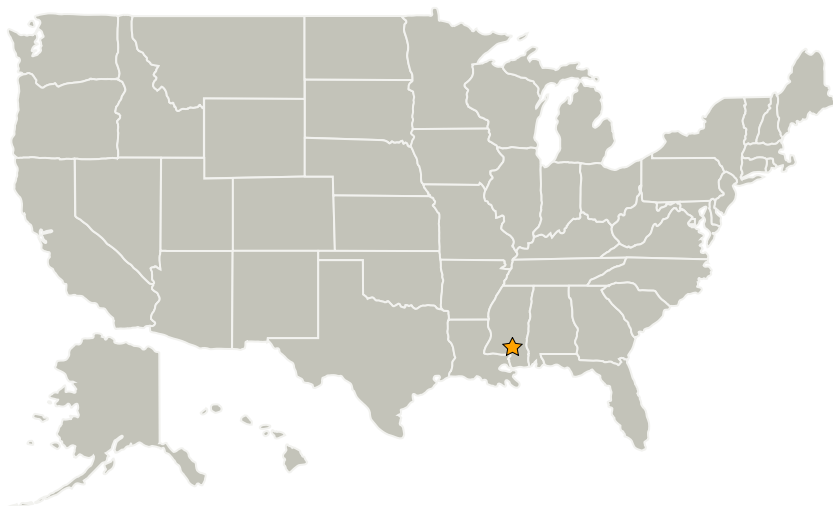
increased control capability. Future iterations could expand the development to create supplementary power generation, new Nitinol engines, and for scaling-up the crawler to enable maneuvering on test hardware.

Anticipated Benefits

The incorporation of a lightweight power efficient miniaturized crawler for retrieving and shelving stored items through a totally new type of locomotion would benefit unfunded NASA missions, by providing a technology that has practical applicability for accessing and transporting hardware components.

Beyond maneuvering test hardware, the Nitinol technology has the potential to recover waste heat and convert the heat into power on a large and small scale for reducing power consumption.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Stennis Space Center(SSC)	Lead Organization	NASA Center	Stennis Space Center, Mississippi

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Stennis Space Center (SSC)

Responsible Program:

Center Innovation Fund: SSC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Ramona E Travis

Project Manager:

Scott L Jensen

Principal Investigator:

Andrew K Bracey

Realizing Practical Nitinol Locomotion

Completed Technology Project (2014 - 2016)



Images



Realizing Practical Nitinol Locomotion

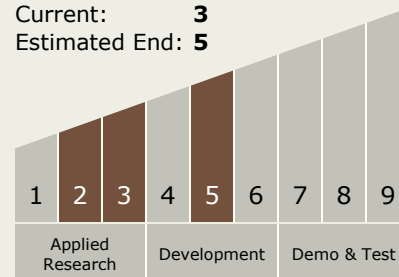
Technology Transfer Program Logo
(<https://techport.nasa.gov/image/16541>)

Project Website:

<https://www.nasa.gov/directorates/spacetech/home/index.html>

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **5**



Technology Areas

Primary:

- TX13 Ground, Test, and Surface Systems
 - └ TX13.3 Assembly, Integration and Launch
 - └ TX13.3.1 Offline Element Processing